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ON THE DIFFERENCE BETWEEN MAGNETIC STORMS WITH SUDDEN AND GRADUAL COMMENCEMENT

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ON THE DIFFERENCE BETWEEN MAGNETIC STORMS WITH SUDDEN AND GRADUAL COMMENCEMENT

(K voprosy o razlichii magnitnykh bur' s vnezapnym i postepennym nachalom)

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By. R. G. Afonina

22593

ABSTRACT.

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The fundamental differences between magnetic storms with sudden and gradual commencement are enumerated. It is further shown that the SC-storms exceed in intensity the G-storms. The dependence of the number of SC-storms upon the phase in the cycle of activity is obtained, namely that during the years of increase in solar activity there are twice as many SC-storms than in the years of decrease. A correlation is noted between the number of SC-storms and the intensity D_{st} of currents within the 11-year cycle.

author

COVER-TO-COVER TRANSLATION

Storms with a sudden or gradual commencement have a series of distinctions. Those with a sudden commencement (SC-storms) follow similarly to the U-measure, the course of the number of sunspots within the 11-year cycle. The maximum of SC-storms coincides with that of sunspot formation. SC-storms had in the current and preceding cycles a two-summit maximum. The coincidence of the number of SC-storms maxima with those of solar activity point to the fact, that SC-storms must be generated by broad streams.

Storms with gradual commencement (G-storms) show a rather complex distribution within the 11-year cycle, poorly coordinated with the distribution of sunspots. The maximum of G-storms corresponds to the years of solar activity drop. The observed retardation of the maximum of G-storms from that of solar activity points to the narrowness of corpuscular streams, responsible for G-storms. Besides, equinoctial maxima are clearly expressed in G-storms, particularly in the years of drop and minimum of solar activity, which allows to speak of the high degree of corpuscular streams' "radiality". Such sharpness in the expression of equinoctial maxima is not characteristic of storms with sudden commencement.

A secular variation is noted for the number of G-storms from one solar activity minimum year to another. This peculiarity is not characteristic of SC-storms.

Finally, G-storms recur every 27 days, and are capable of forming long sequences, which points to the stability of the corpuscular streams generating them.

As a rule, storms with sudden commencement do not form sequences, which tends to indicate streams of short duration, responsible for them. All this lays basis for the assumption that storms with sudden commencement (SC-storms) and those with gradual commencement (G-storms) are of different nature. It is thus interesting to refer to the basic conclusions drawn by N. P. Ben'kova [2] in respect to 11-year variations of D_{st} and S_D- currents. The configuration from year to year of these currents varies very little. What basically varies, is their intensity, which she designated by I_{st} and I_{sD}. Cyclical oscillations of electric currents D_{st} and S_D-variations (curves I_{st} and I_{s_D} respectively), are plotted by the author in a graph (see Fig. 34 of reference [2]), together with the variations of the relative number of sunspots (W).

N. P. Ben'kova notes a comparatively poor correspondence between I_{st} and I_{s_D}, which becomes particularly interesting, if one takes into account that the intensity of either current system is computed according to the same data of the X- component of the Wankayo observatory. This poor correspondence constituted one of the indications on the different nature of current systems, while the I_{st} -currents appear to be more closely linked with the distribution of sunspot number. During the years 1919-1950, examined by Ben'kova, and which encompassed 16, 17 and 18 cycles, I_{st} had a two-summit maximum in 16 and 18 cycles, and also U -measure and SC-storms.

The S_D -current oscillations are much more complex, and they do not reveal a good agreement with the course of the relative number of sunspots. N. P. Ben'kova shows that after 1938 the magnitudes I_{sD} continue to grow almost monotonously, reaching very high values during the minimum years (1943, 1944). Disposing only of the material accoring to two cycles, it is difficult to explain this phenomenon. This conclusion relative to I_{sD} agrees well with the conclusion relative to storms with gradual commencement. In the last cycle, the number of storms with gradual commencement, rising monotonously, reaches the maximum in the year of low solar activity (1952). In the preceding cycle the distribution of G-storms is till more complex : two maxima are noted in 1940 and 1943, i. e. the maximum of I_{sD}-currents in 1943 coincides with the maximum of G-storms in the same year. In an earlier cycle, Ben'kova noted an entirely different character of I_{sD} variation. During certain years of high solar activity (1927, 1928, 1937), the eddy's center splits, i. e. two maxima are revealed in the S_D (for the H-component) of Wankayo . The law of I_{sD} variation in the 16th cycle (overlapping of the two-summit maximum with that of solar activity) is rather inherent to the U-measure and to SC-storms. If we take into account that the U-measure is the measure of the field "after disturbance", this law must be also preserved for D_{st}- currents.

The S_D-current oscillations are generally subject to more complex rules than the S_{st}-currents. But the fact that the distribution of S_D- currents does not disclose a good correspondance with the course of relative numbers of sunspots, makes them comparable with the storms having a gradual commencement (see Fig. 1 & 2, ref.[1]).

TABLE 1.

Number of Storms with Sudden and Gradual Commencement by categories in every year for the period 1940-1959.

Year	All or SC	Category of Storms: moderate	great	very great	Total number
1940	all	16	11	4	31
	SC	1	6	4	11
1941	all	10	6	7	23
	SC	0	1	4	5
1942	all	13	6	2	21
	SC	4	1	1	6
1943	all	30	4	0	34
	SC	1	0	0	1
1944	all	13	1	2	16
	SC	3	0	1	4
1945	all	18	3	0	21
	SC	4	0	0	4
1946	all	21	2	7	30
	SC	8	1	6	15
1947	all	18	8	3	29
	SC	6	6	2	14
1948	all	26	8	1	35
	SC	8	2	1	11
1949	all	17	3	4	24
	SC	7	2	4	13
1950	all	21	7	0	28
	SC	7	3	0	10
1951	all	27	6	3	36
	SC	5	1	1	7
1952	all	30	6	0	36
	SC	2	1	0	3
1953	all	17	4	1	22
	SC	2	0	0	2
1954	all	12	0	0	12
	SC	1	0	0	1
1955	all	9	3	1	13
	SC	0	2	0	2
1956	all	21	11	0	32
	SC	8	6	0	14
1957	all	21	7	7	35
	SC	6	6	7	19
1958	all	24	8	4	36
	SC	4	6	4	14
1959	all	26	8	4	38
	SC	8	6	3	17

To sum-up the aforesaid, we may draw the following conclusions :

— D_{st}-current, the U-measure, and the SC-storms are subject to a single law of the 11-year distribution, which is basically characterized by a good agreement with the course of the relative number of sunspots and the maxima'coincidence. A poor correspondence with the distribution of the relative number of sunspots is noted for S_D -currents and for G-storms.

— Storms with sudden and gradual commencement, as well as the D_{st}- and S_D-currents differ in their intensity. This conclusion may be made on the basis of statistical tabulations brought out in Table 1.

It may be seen from that Table that 76% of all very great storms for a twenty-year period had a sudden beginning, 45% of all great storms and 22% of the moderate storms were in the same case. Therefore, it may be said that, as a rule, very great storms have a sudden commencement, and the moderate ones — a gradual commencement. Taking for 100 percent the number of storms with a sudden commencement and correspondingly that with gradual commencement, we shall obtain correlations (Table 2) which show, that SC-storms may be estimated, as an average, as great storms, whereas G-storms may be considered as moderate. Thus, the conclusion may be drawn, that SC-storms exceed the G-storms in intensity.

Table 2.

Category of Storms	1940-1959			
	SC-storms		G-storms	
	number	%	number	%
Moderate	85	49	305	80
Great	50	29	62	16
Very great	38	22	12	3
Total number	173	100	379	100

Still another peculiarity may be noted for SC-storms. Their number varies for years of increased and decreased solar activity. In order to trace this, the 20-year period (1940-1959) was broken up in years of solar activity decrease (1940-1944, 1950-1954) and in years of increase (1945-1949, 1955-1959).

It resulted (Table 3) that during years of solar activity decrease, 22% of the storms had a sudden commencement, while during the years of increase 45% of them were so characterized.

Hence it follows that during the years of solar activity increase, there are twice as many SC-storms, as in the years of its decrease.

TABLE 3.

Number of Storms with a Sudden and Gradual Commencement during the Years of Decrease (1940-1944, 1950 - 1954) and Decrease (1945-1949, 1955 – 1959) in Solar Activity

Category of Storms	Solar activ. decrease					Solar activ. increase				
	all	SC	%	G	%	all	SC	%	G	%
Moderate	189	26	14	163	86	182	59	32	123	68
Great	51	13	25	38	75	61	37	61	24	39
Very Great	19	11	58	8	42	31	27	87	4	13
Total Number	259	56	22	209	78	274	123	45	151	55

Opposite deductions were arrived at by V. I. Afanas'yeva [3], who asserts in her work :

a) that the relative number of SC-storms does not depend upon the ph se of the activity cycle in a simple fashion,

b) that SC- and G-storms of any intensity are met with.

Besides, the revision of magnetograms has demonstrated, as Afanas'yeva points out, that sudden commencements or impulses, are encountered in the majority of storms and disturbances of any intensity. Thus, SC-storms lose their exclusivity.

The conclusions reached in the current work allow the subdivision of the storms into two types, and the assumption that streams, responsible for both types of storms, must also differ in their intensity. Dorman [4] also arrives at the same conclusion : On the basis of the study of data on cosmic rays, he subdivides corpuscular streams according to their properties into streams of the first and second type. Just as the streams of the first type, those responsible for G-storms are less intense, and they cause basically weak and moderate magnetic disturbances at reaching the Earth. Streams responsibles for SC-storms may be related to those of the second type by their properties, as they bear "frozen-in" magnetic fields of substantial intensity, and at hitting the Earth they mostly provoke great and very great magnetic storms. Just as the SC-storms, the second type streams correlate well with the relative sunspot numbers, while those of the first type and the G-storms show a poor agreement.

The significant increase in the number of SC-storms during the years of solar activity increase (Table 3) may be explained by more favorable conditions for corpuscular stream's yield. A sharp variation in the surfaces of sunspot groups, and the appearance in them of maximum magnetic fields takes place precisely in the years of solar activity increase. The sharp variation of magnetic fields may lead to the formation of powerful electric fields, whose joint action will contribute to corpuscular stream yield (egress).

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